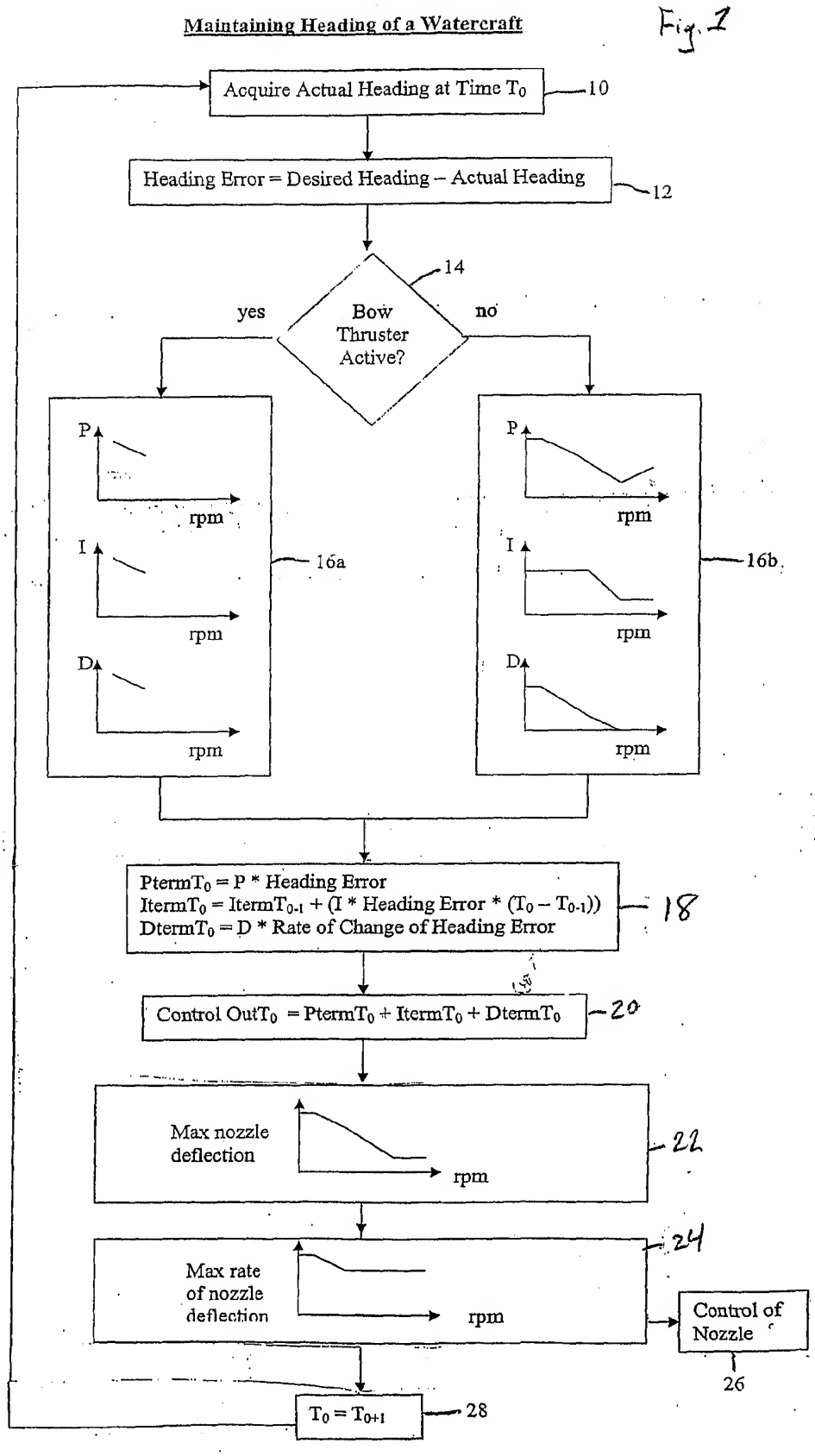
Maintaining Heading of a Watercraft
Fig. 1
Acquire Actual Heading at Time T_0
10
Heading Error = Desired Heading – Actual Heading
12
14
Bow Thruster Active?
yes
no
P
rpm
I
rpm
D
rpm
16a
16b
$PtermT_0 = P * Heading Error$
$ItermT_0 = ItermT_{0-1} + (I * Heading Error * (T_0 - T_{0-1}))$
$DtermT_0 = D * Rate of Change of Heading Error$
18
$Control\ Out T_0 = PtermT_0 + ItermT_0 + DtermT_0$
20
Max nozzle deflection
rpm
22
Max rate of nozzle deflection
rpm
24
Control of Nozzle
26
$T_0 = T_{0+1}$
28

Approximate Heading From A Filtered Heading Sensor During A Turn

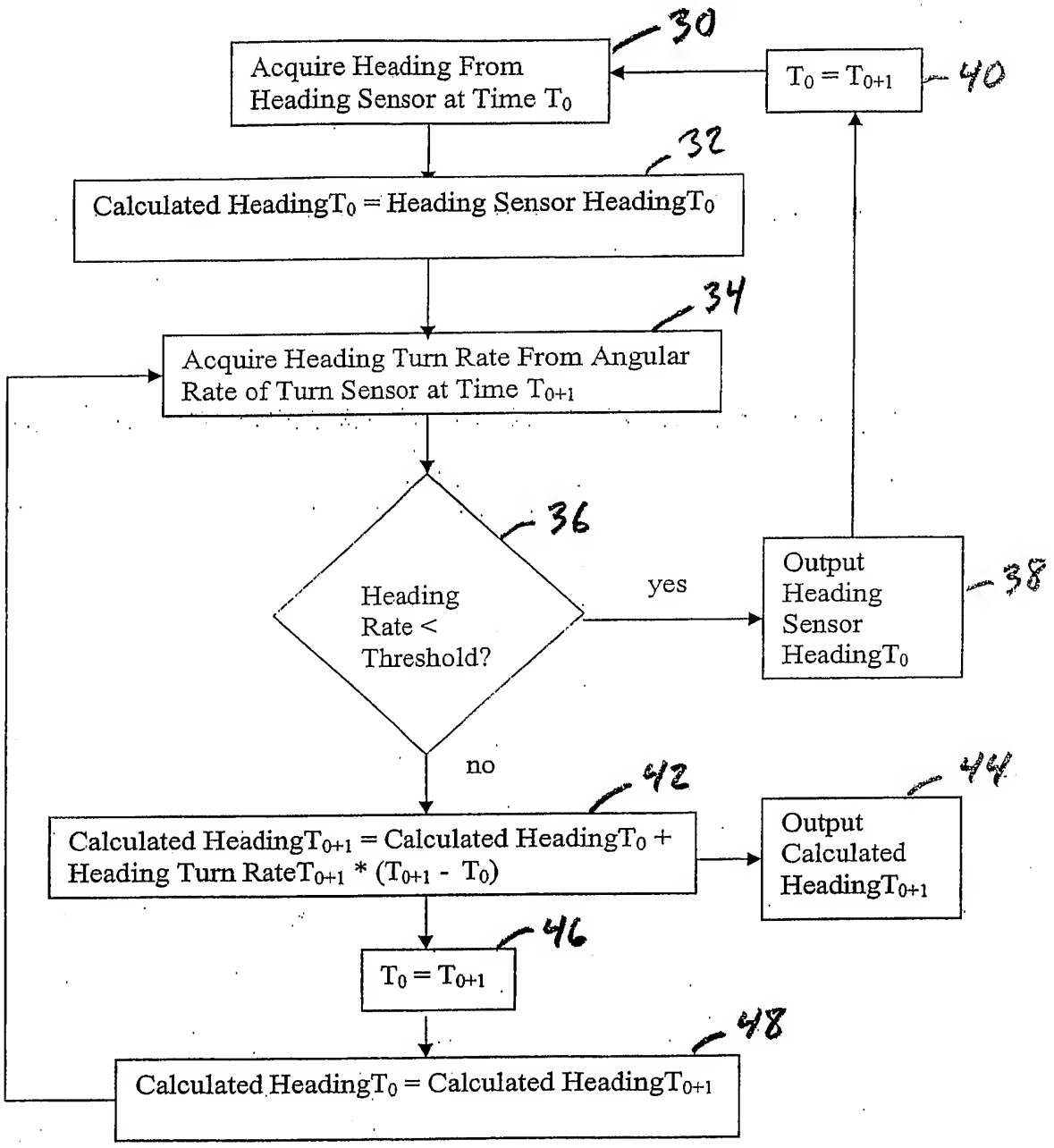

FIG. 2

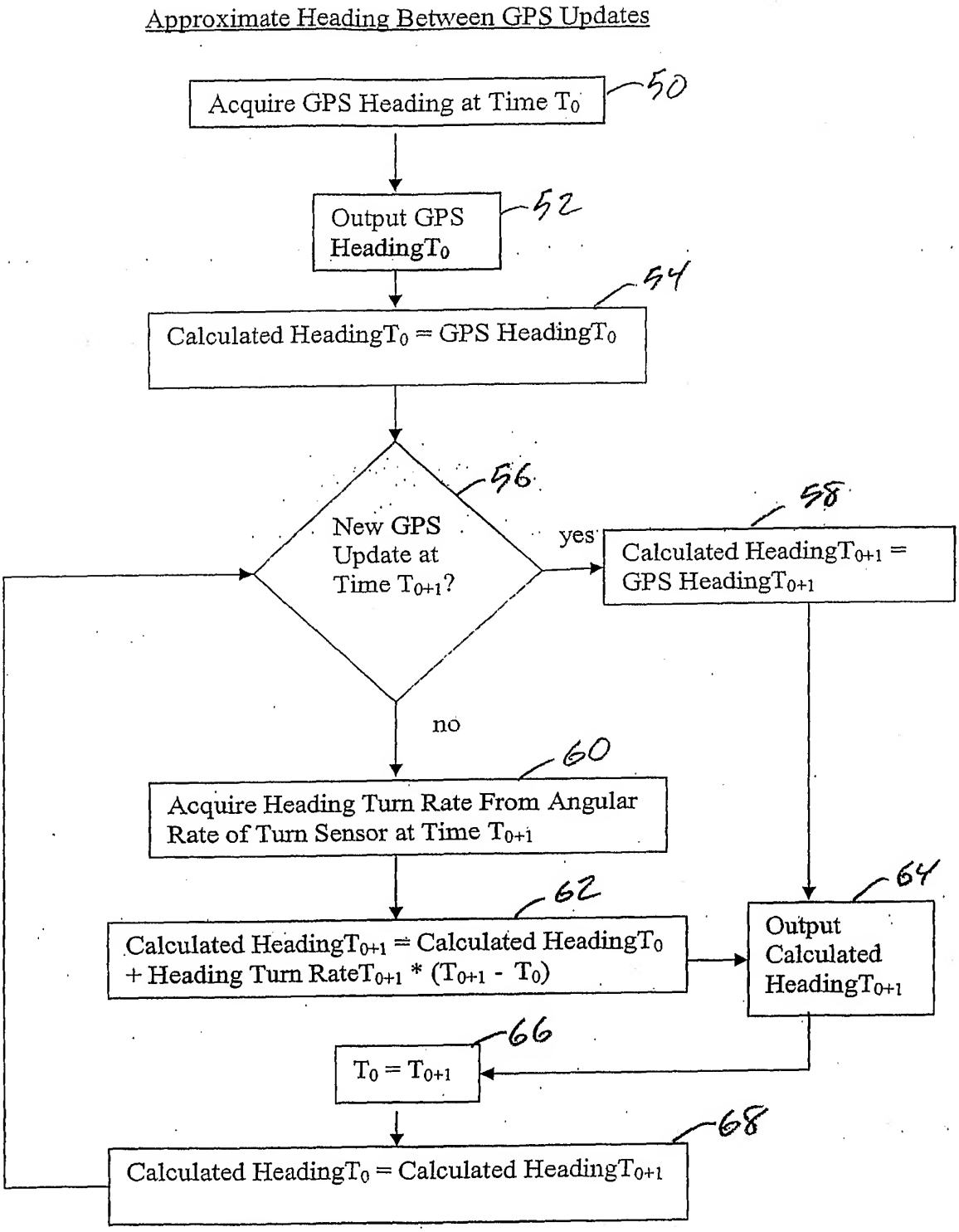
Approximate Heading Between GPS Updates
Acquire GPS Heading at Time T_0
50
Output GPS HeadingT_0
52
Calculated HeadingT_0 = GPS HeadingT_0
54
New GPS Update at Time T_{0+1}?
56
yes
Calculated HeadingT_{0+1} = GPS HeadingT_{0+1}
58
no
Acquire Heading Turn Rate From Angular Rate of Turn Sensor at Time T_{0+1}
60
Calculated HeadingT_{0+1} = Calculated HeadingT_0 + Heading Turn RateT_{0+1} * (T_{0+1} - T_0)
62
Output Calculated HeadingT_{0+1}
64
T_0 = T_{0+1}
66
Calculated HeadingT_0 = Calculated HeadingT_{0+1}
68

FIG. 3

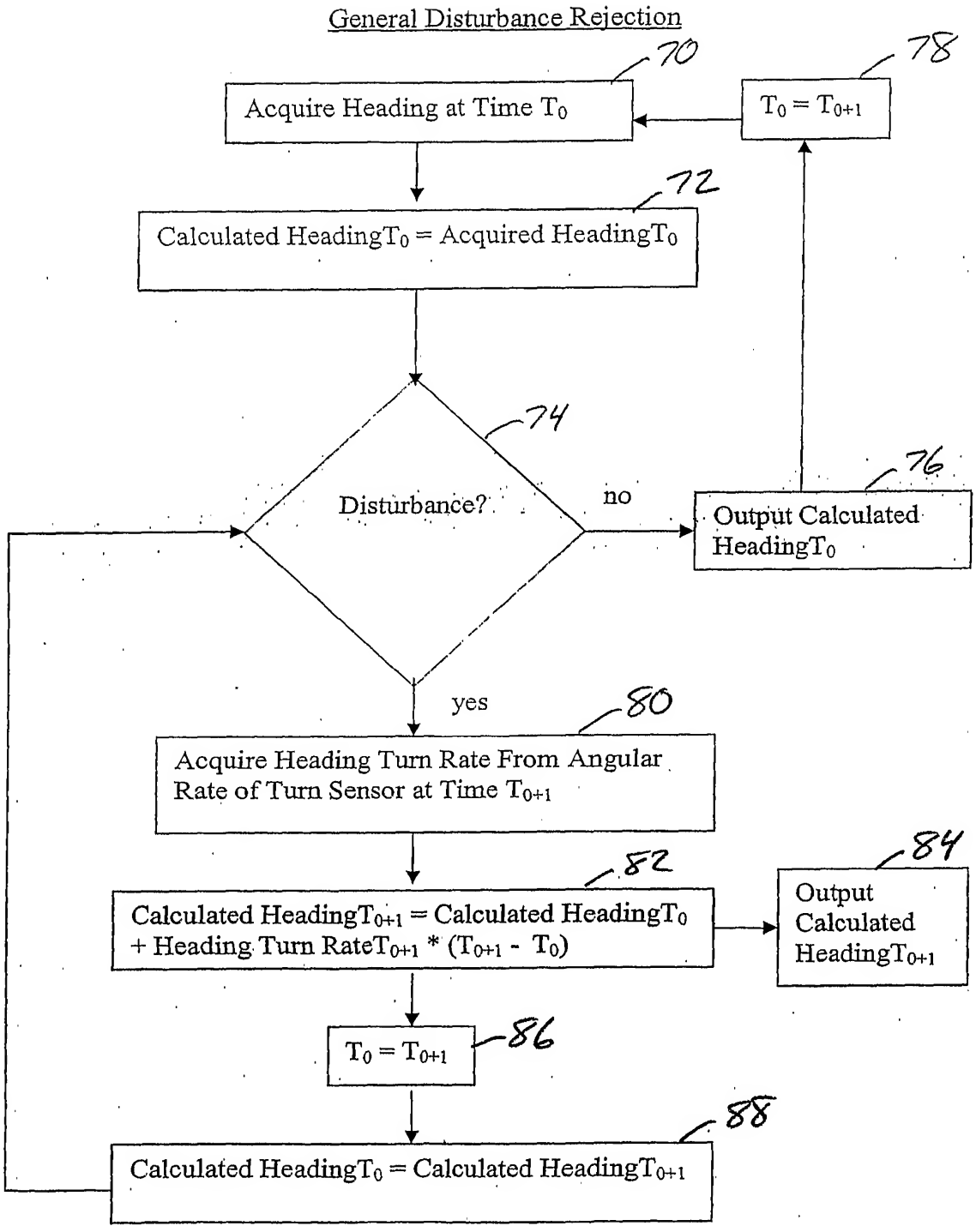
General Disturbance Rejection
70
Acquire Heading at Time T_0
78
$T_0 = T_{0+1}$
72
Calculated HeadingT_0 = Acquired HeadingT_0
74
Disturbance?
no
76
Output Calculated HeadingT_0
yes
80
Acquire Heading Turn Rate From Angular Rate of Turn Sensor at Time T_{0+1}
82
Calculated HeadingT_{0+1} = Calculated HeadingT_0 + Heading Turn RateT_{0+1} * (T_{0+1} - T_0)
84
Output Calculated HeadingT_{0+1}
86
$T_0 = T_{0+1}$
88
Calculated HeadingT_0 = Calculated HeadingT_{0+1}

FIG. 4

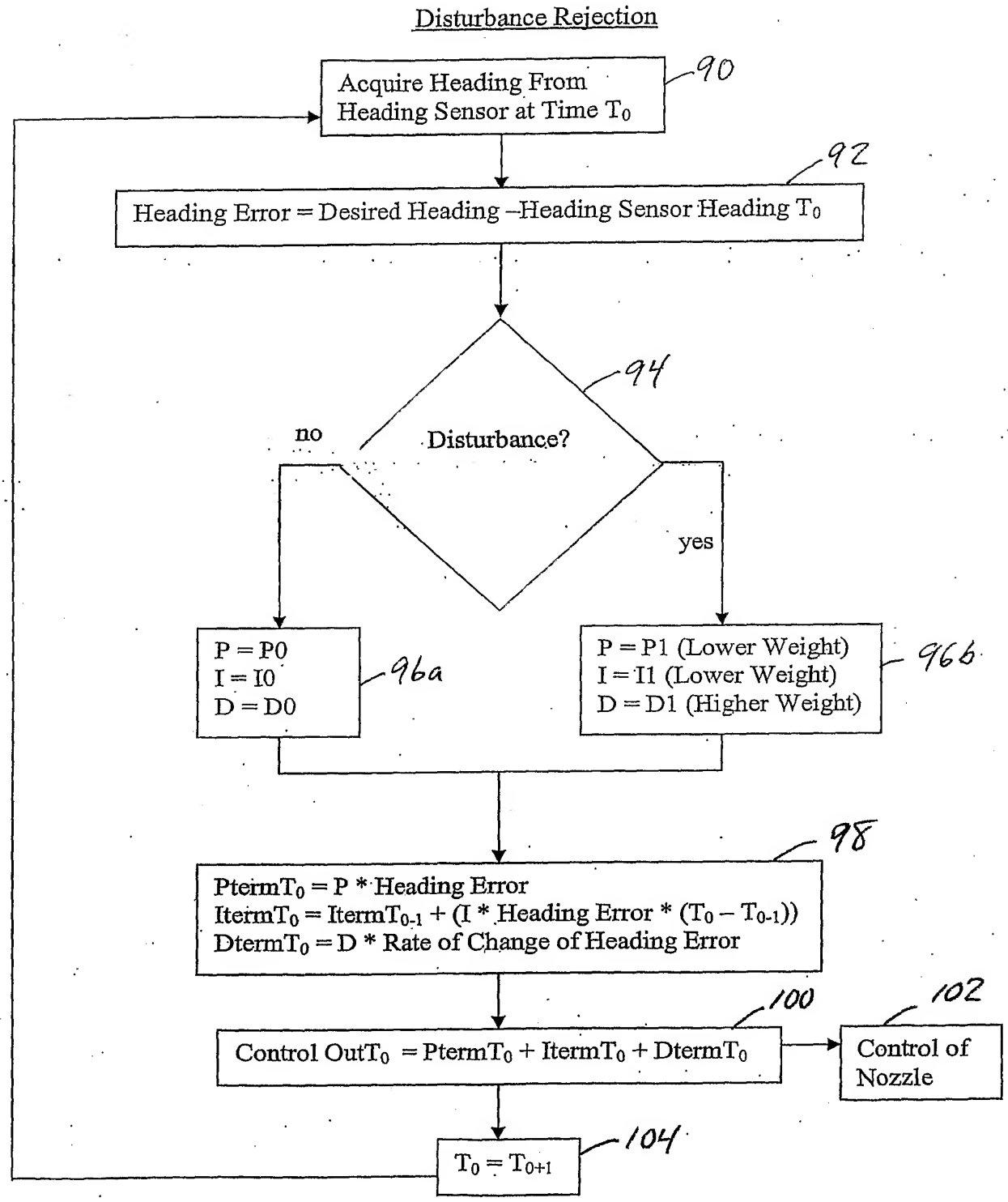
Disturbance Rejection
Acquire Heading From Heading Sensor at Time T_0
90
Heading Error = Desired Heading –Heading Sensor Heading T_0
92
Disturbance?
94
no
yes
P = P0
I = I0
D = D0
96a
P = P1 (Lower Weight)
I = I1 (Lower Weight)
D = D1 (Higher Weight)
96b
$PtermT_0 = P * Heading Error$
$ItermT_0 = ItermT_{0-1} + (I * Heading Error * (T_0 - T_{0-1}))$
$DtermT_0 = D * Rate of Change of Heading Error$
98
Control $OutT_0 = PtermT_0 + ItermT_0 + DtermT_0$
100
Control of Nozzle
102
$T_0 = T_{0+1}$
104

FIG. 5

Disturbance Rejection With Predetermined Data Correction

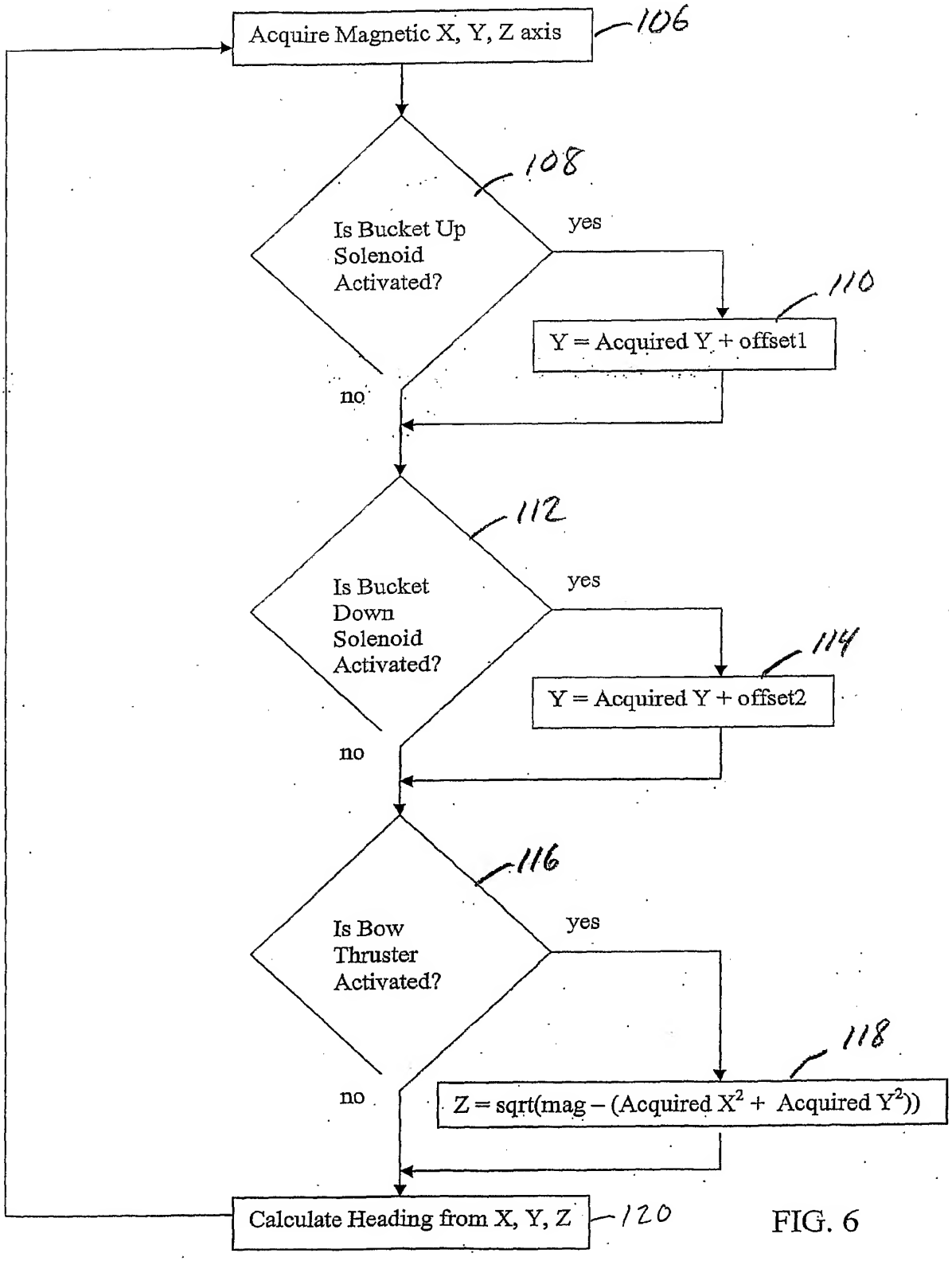

FIG. 6

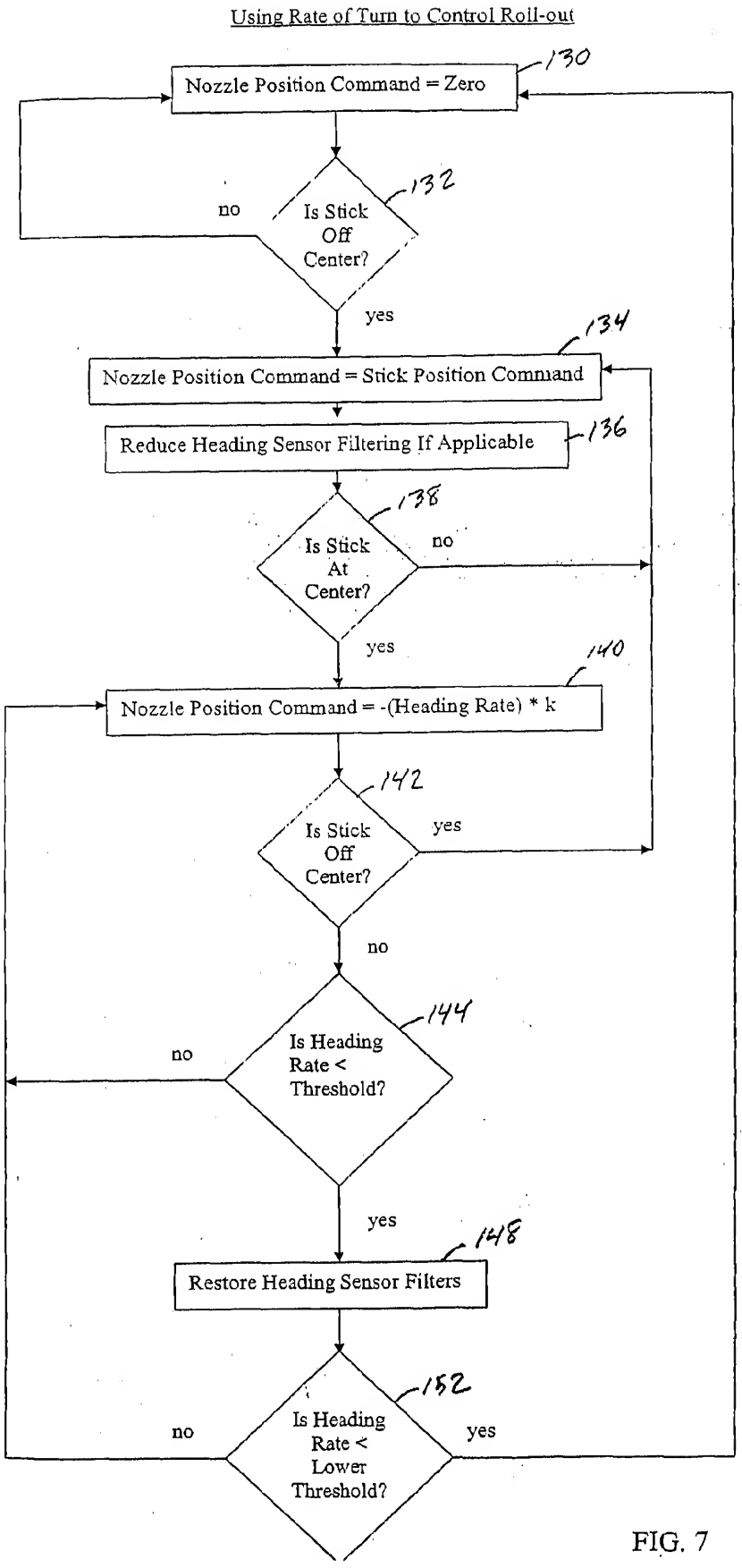
Using Rate of Turn to Control Roll-out
Nozzle Position Command = Zero
130
Is Stick Off Center?
132
no
yes
Nozzle Position Command = Stick Position Command
134
Reduce Heading Sensor Filtering If Applicable
136
Is Stick At Center?
138
no
yes
Nozzle Position Command = -(Heading Rate) * k
140
Is Stick Off Center?
142
yes
no
Is Heading Rate < Threshold?
144
no
yes
Restore Heading Sensor Filters
148
Is Heading Rate < Lower Threshold?
152
no
yes

FIG. 7